

WHAT IS CLAIMED IS:

1. A magnetic structure for generating a uniform magnetic field capable of implementing NMR imaging of the head of a patient within a region of interest, comprising:

a) first and second magnetic structures defining a first cavity having the region of interest and configured to accommodate the head of a patient and defining adjacent the first cavity a second cavity, larger than the first cavity, configured to accommodate the shoulders of the patient when the latter's head is positioned in the first cavity, the first and second magnetic structures being positioned on opposite sides of the first and second cavities and defining a common longitudinal axis through the centers of the first and second magnetic structures and providing access if desired from the outside for surgical intervention to the head of the patient when positioned within the first cavity,

b) each of the first and second magnetic structures comprising a magnetic structure including:

i) an annular section of permanent magnetic material and having a conical portion having a narrower end and a wider end and substantially inner and outer conical surfaces and a conical axis coincident with the common longitudinal axis, the narrower end being positioned closer to the region of interest than the wider end, the permanent magnetic section having a first value and a first orientation of remanence,

ii) a pole piece member of ferromagnetic material and positioned within the conical section adjacent and bordering its inner conical surface and having an axis also coincident with the common longitudinal axis, the annular surface of contact between the inner conical surface of the permanent magnetic section and the bordering pole piece member being slightly curved,

c) the permanent magnetic sections and the pole piece members of the first and second magnetic structures cooperating to produce within the first cavity a substantially uniform magnetic field capable of supporting NMR imaging,

d) the shape of the annular curved surface of contact being configured so as to form at that surface an equipotential surface, whereby distortion of the substantially uniform magnetic field is minimized.

2. A magnetic structure as claimed in claim 1, wherein each of the permanent magnetic sections of the first and second magnetic structures further comprises a first cylindrical magnetic section extending radially in a direction away from the common longitudinal axis and integral with the conical section.

3. A magnetic structure as claimed in claim 2, wherein each of the pole piece members have an inner surface bounding the first cavity and an outer surface remote from the first cavity, each of the permanent magnetic sections of the first and second magnetic structures further comprising a second cylindrical magnetic section integral with the first cylindrical section and extending over the outer surface of the adjacent pole piece member.

4. A magnetic structure as claimed in claim 3, wherein the conical portion and the first and second cylindrical magnetic sections of each of the first and second magnetic structures form a one-piece integral permanent magnetic body.

5. A magnetic structure as claimed in claim 4, wherein the one-piece integral permanent magnetic body of each of the first and second magnetic structures is magnetized with an orientation parallel to the common longitudinal axis.

6. A magnetic structure as claimed in claim 3, wherein each of the second cylindrical magnetic sections bound a non-magnetic region aligned with the common longitudinal axis.

5. A magnetic structure as claimed in claim 6, wherein the non-magnetic regions of each the second cylindrical magnetic sections are positioned at predetermined locations selected such as to establish magnetostatic potentials that support the substantially uniform magnetic field.

8. A magnetic structure as claimed in claim 1, wherein the annular curved surface of contact is concave and faces away from the common longitudinal axis.

9. A magnetic structure as claimed in claim 1, wherein the first and second magnetic structures are configured such that the second cavity surrounds the first cavity and both the first and second magnetic structures are circular symmetric about the common longitudinal axis.

10. A magnetic structure as claimed in claim 1, further comprising a yoke magnetically connected to the first and second magnetic structures.

11. A magnetic structure as claimed in claim 1, wherein the ferromagnetic pole piece member of each of the first and second magnetic structures has a high permeability and a generally conical shape.

12. A method of designing a magnetic structure for generating a uniform magnetic field capable of implementing NMR imaging of the head of a patient within a region of interest, the magnetic structure comprising:

a) first and second magnetic structures defining a first cavity having the region of interest and configured to accommodate the head of a patient and defining adjacent the first cavity a second cavity, larger than the first cavity, configured to accommodate the shoulders of the patient when the latter's head is positioned in the first cavity, the first and second magnetic structures being positioned on opposite sides of the first and second cavities and defining a common longitudinal axis through the centers of the first and second magnetic structures and providing access if desired from the outside for surgical intervention to the head of the patient when positioned within the first cavity,

b) each of the first and second magnetic structures comprising a magnetic structure including:

i) an annular section of permanent magnetic material and having a conical portion having a narrower end and a wider end and substantially inner and outer conical surfaces and a conical axis coincident with the common longitudinal axis, the narrower end being positioned closer to the region of interest than the wider end, the permanent magnetic section having a first value and a first orientation of remanence,

ii) a pole piece member of ferromagnetic material and positioned within the conical section adjacent and bordering its inner conical surface and having an axis also coincident with the common longitudinal axis, the annular surface of contact between the inner conical surface of the permanent magnetic section and the bordering pole piece member being slightly curved,

c) the permanent magnetic sections and the pole piece members of the first and second magnetic structures cooperating to produce within the first cavity a substantially uniform magnetic field capable of supporting NMR imaging,

comprising the steps:

A) choosing the head and shoulder cavity dimensions that will accommodate the head and shoulders of an ordinary patient;

B) choosing suitable angles to accommodate the shoulders of the patient and not extend unnecessarily the overall dimensions of the structure;

C). choosing the permanent magnetic material to use which determines its remanence J which with a typical value of K determines the desired uniform field intensity H_0 in the first cavity;

D) the coordinates of a point C10 on the annular surface of contact adjacent the first cavity and the magnetostatic potential being determined by the choices made in steps A-C ;

E) maintaining constant the magnetostatic potential Φ determined in step D, determining the coordinates for at least several more points along the annular surface of contact by calculation from Equation 2.1 for $\Phi = C_0$ to determine a profile for the annular surface of contact;

F) constructing the annular section of permanent magnetic material using the profile determined in step E and assembling to the remainder of the magnetic structure.

13. A method as set forth in claim 12, further comprising the step:

H) before step F, repeating step E to determine the shape of the upper part of the annular section of permanent magnetic material to be assembled to the remainder of the magnetic structure.

14. A method as set forth in claim 12, further comprising the steps:

H) providing an opening in the upper part of the annular section of permanent magnetic material adjacent the longitudinal axis, the opening being positioned to minimize field distortions in the region of interest;

I) shaping the outer surface of the pole piece member of ferromagnetic material to conform to the profile determined in step E.